Fetuses as a high-risk group for MeHg toxicity: Specificity of MeHg transfer through the placenta

Mineshi Sakamoto
Director, Department of Environmental Science and Epidemiology / International Affairs and Research, National Institute for Minamata Disease, Minamata, Japan

Background: Fetuses depend on their mothers for nutrition, including essential elements such as zinc (Zn), copper (Cu), and selenium (Se). However, they are also exposed through their mothers to toxic elements such as methylmercury (MeHg), inorganic mercury (I-Hg), lead (Pb), and cadmium (Cd).

Objectives: The role of the placenta in the maternal-fetal transfer of the above-mentioned toxic and essential elements was assessed in freeze-dried chorionic placental tissue and umbilical cord tissue. The significance of the placenta and cord tissue as predictors of prenatal exposure to these trace elements in pregnant women and newborns was also examined by comparing the profiles of these elements in placenta with those in cord tissue, and by comparing their profiles in maternal and cord blood red blood cells (RBCs). The samples were collected at birth from 48 mother-child pairs recruited from the general Japanese population.

Results and Discussion: The concentrations of all elements, except MeHg, were significantly higher in the placenta than in cord tissue. Cd had the highest placenta vs. cord tissue ratio (59:1), followed by I-Hg (2.4:1), indicating that of all the toxic elements examined, the placental barrier works most effectively against Cd. In comparison, the MeHg concentration in cord tissue was significantly higher (1.6 times) than that in the placenta, indicating exceptionally high placental transfer. MeHg concentrations in the placenta were significantly correlated with total mercury (T-Hg) concentrations in maternal and cord RBCs (r_s = 0.80 and 0.91, respectively). The MeHg concentration in cord tissue was also significantly correlated with T-Hg concentrations in maternal and cord RBCs (r_s = 0.75 and 0.85, respectively). Therefore, both placenta and cord tissue are useful for evaluating maternal and fetal exposure to MeHg. The concentrations of Pb, Zn, and Cu in placenta and cord tissue showed no significant correlations with those in cord and maternal RBCs. However, the Cd concentration in the placenta was significantly correlated (r_s = 0.41) with that in maternal RBCs, suggesting that the placenta is useful for evaluating maternal exposure to Cd during gestation.

Conclusion: The developing fetal brain during the prenatal stage is highly susceptible to damage from environmental toxins. Toxic metals such as Cd, I-Hg, and Pb are sequestered within the placenta. However, the placenta is not effective in preventing the transfer of MeHg to the fetus. This specific MeHg accumulation in fetal tissue, relative to concentrations in the mother, is an important public health issue.

In this presentation, I also introduce the history of Minamata disease, the important precautionary lessons the disease provides, and the international research activities of the National Institute for Minamata Disease as a collaborating center of the WHO.

メチル水銀のハイリスクグループとしての胎児：
メチル水銀の胎盤通過の特異性

坂本　峰至
環境省 国立水俣病研究センター
国際・総合研究部/環境・疫学研究部　部長

胎児は亜鉛（Zn), 銅（Cu), セレン(Se)の必須元素を含む栄養素を母親に依存している。しかし、彼らはメチル水銀（MeHg), 無機水銀（I-Hg), 鉛（Pb）カドミウム（Cd）の有害金属へも母体を介して曝露される。胎盤の役割を凍結乾燥した胎盤絨毛組織と臍帯の上記元素組成を比較することで評価した。母親や胎児の出産前における、これらの元素への曝露指標としての胎盤や臍帯の意義についても、胎盤、臍帯、母体血および臍帯血赤血球間の元素組成を比較することで検討した。サンプルは出産時の 48 組の母親と児から採取された。

MeHg を除く全ての元素は、臍帯より胎盤で高かった。特に Cd は胎盤対臍帯比(59:1)と高く、I-Hg (2.4:1)と続いた。胎盤関門は特に Cd に対して有効に働いていることが示唆された。他の元素とは逆に、MeHg の濃度は臍帯が胎盤より有意に高（1.6 倍）く、例外的に高い胎盤通過性が示唆された。胎盤の MeHg は母体血と臍帯血の赤血球中総水銀と有意な相関を示した(r_s = 0.80 and 0.91, respectively)。臍帯の MeHg も母体血と臍帯血の赤血球中総水銀と有意な相関を示した(r_s = 0.75 and 0.85, respectively）。それゆえ、胎盤と臍帯も母親や胎児の MeHg への曝露指標となりうる。胎盤と臍帯の Pb, Zn, Cu 濃度は母体血と臍帯血のそれら元素の濃度と有意な相関を示さなかった。例外的に、胎盤の Cd は母体血の Cd と有意な(r_s = 0.41）相関を示し、妊娠期間中の母親への Cd の曝露指標として有用であることが示唆された。

出生前の発達中の脳は環境中毒性物質に感受性が高いことが知られている。Cd, I-Hg, Pb の有害金属は胎盤中にトラップ（捕囚）されていた。しかし胎盤は MeHg の捕囚に働いていなかった。この特異的な、母親より児に高い MeHg の蓄積性が公衆衛生上重要な点である。

本発表では、水俣病の歴史、そこから学ぶ予防原則の重要性及び国立水俣病総合研究センターの WHO 協力機関としての国際調査活動についても紹介する。